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by

Albert L. Johnson [1]

INTRODUCTION

American Iron and Steel Institute's Specification for the Design of Cold-Formed Steel Structural Members was first published in 1946. A number of revisions have been published since that time reflecting improvements in design techniques, the results of continuing research programs and the changing and growing needs of the users of cold-formed steel structures.

This paper describes the methods used for preparing and reviewing changes in the specification, surveys recently approved changes and additions in the specification and currently proposed modifications, and notes potential future revisions.

ADVISORY GROUP

The Advisory Group on the Specification was formed in 1973 to involve many individuals representing wide experience and knowledge in cold-formed steel applications, design, and construction. The increasing scope and depth of the specification, the needs of users of the specification, and the growing professional awareness of cold-formed steel structural design; combined with the importance of broad participation in specification writing activities all contributed to development of the concept of the Advisory Group.

The functions of the Advisory Group include:

1. Recommend and/or review proposed modifications and extensions of the specification and commentary.
2. Maintain awareness of design techniques and the need of users of the specification.

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3. Recommend research necessary to keep the specification current and responsive to producers' and users' needs.
4. Review research and other activities as necessary to correlate results with the specification.

The Advisory Group functions under the specification writing authority of AISI's Committee on Construction Codes and Standards, and is sponsored by AISI's Sheet Committees. The membership of the Advisory Group is classified into three categories - producer, consumer, and general interest. By intent, the total number of producers cannot exceed the total of consumer and general interest members. Present membership, shown in Table 1, includes 11 producers, 6 consumers, and 13 general interest members with voting privileges, as well as two non-voting associate members. Members are selected primarily on the basis of personal expertise, but care has and is taken to see that liaison is maintained with other interested groups through the activities of the individual members. The membership is reviewed annually, and changes made as necessary. Table 2 lists those individuals who have been members of the Advisory Group since its inception in 1973, but who no longer serve in that capacity.

The first chairman of the Advisory Group was R. B. Matlock, then from Stran-Steel Corporation. The Advisory Group had its major growing pains under his direction, developing working procedures and getting the new activity off to a good start. The second chairman of the Advisory Group was D. S. Wolford, then from Armco Steel Corporation. The first major specification changes since the 1968 edition were approved during Don Wolford's chairmanship. In 1977, K.H. Klippstein of U. S. Steel Corporation assumed the chairmanship.

The Advisory Group meets at least once a year; usually twice. A typical agenda includes discussion of the results of recent ballots, resolution of differing opinions on proposed changes in the specification, development of background for the members on items to be balloted in the near future, and proposals

of new topics for possible preparation of changes for balloting. Consistent with its function, the Advisory Group also regularly reviews research in progress, and often proposes changes in the course of research projects as well as new topics requiring special study. Voting procedures are rigorous and carefully adhered to. At least 75 percent must vote on a change in the specification, always balloted by mail. Of those voting, at least 75 percent must approve any proposed change. Further protection is given to the minority view in that all negative ballots accompanied by reasons for the negative, as well as any affirmative ballots with comments on the substance of the proposed change, or the editorial character of the change, must be reviewed and resolved before final approval of the change.

The regular meetings of the Advisory Group are supported by a number of subcommittees established to study particular specification changes or areas where changes must be developed. Often the subcommittees are named when a research project specifically designed to develop background for improvements in the specification has progressed to a point where technical evidence to support revisions is available. The same subcommittees or other especially established subcommittees may be assigned topics covering areas where the specifications may have been found to be deficient in some way or where special problems have arisen.

Since the Advisory Group was established, its responsibilities have grown, and its impact is readily seen. Membership on the Advisory Group represents a personal sacrifice and contribution of time for all involved, and a particularly significant contribution by those consultants and academicians for whom it represents unpaid time and effort. The value of the total of the volunteer effort to the user of the specification is immense.

1968 SPECIFICATION

The current edition of the cold-formed specification was published in 1968. It was a major revision of the previous (1962) edition, and included design procedures for compression members subject to torsional-flexural behavior, and an

analytical procedure for utilization of strengthening caused by the cold work of forming. The 1968 edition also reflected an extensive effort to correlate the cold-formed specification with AISC's Specification for the Design, Fabrication, and Erection of Structural Steel for Buildings.

APPROVED CHANGES AND ADDITIONS

At the time of this writing (February 1978), two addenda to the 1968 specification have been published. Both are covered in addendum no. 2, dated February 4, 1977.

Materials

The scope of the specification has been extended to cover cold-formed members up to one inch in thickness. As a consequence, ASTM specifications listed in the materials clause have been expanded to include plate and bar steels, as well as sheet steels. This expansion to thicker steels was stimulated by the increased capacity of cold-formed equipment, and was validated by a research project directed by Prof. Wei-Wan Yu at the University of Missouri-Rolla.

Delivered Minimum Thickness

A new clause covering delivered minimum thickness was included in addendum no. 2. The need for this clause was a consequence of some members being designed to a given thickness, but fabricated from a significantly lesser thickness so that the margin of safety of the member in the structure could be significantly less than that intended by the designer. The provision simply states that the uncoated minimum thickness of the cold-formed product, as delivered to the job site shall not be less than 95 percent of the design thickness. An exception is made for the thickness at bends such as corners where the cold-forming may result in a thickness slightly less than the unformed thickness.

Web Design

The interaction of bending stress and web crippling in flexural members is also covered in addendum no. 2. The new provision calls for a reduction factor

to be applied to a concentrated load or reaction when the moment exceeds 30 percent of the maximum allowable bending moment if bending stress only exists. This particular provision for the interaction of bending and crippling has resulted in concern by the manufacturers' of steel deck and metal buildings, and is currently the subject of intensive investigation by the Advisory Group. Additional technical information is being sought from all possible sources to determine if the change is excessively restrictive for certain types of members and in certain applications.

Bolted Connections

A major change in the design provisions for bolted connections was approved on January 25, 1978. Ultimate strength rather than yield point will be used as the basis for calculation of bolt spacing, edge distance, tension stress on net section, and bearing stress. The change also includes reference to installation procedures, a revision of the minimum spacing and edge distances of bolts, addition of criteria for bolted connections without washers and increase of the allowable shear on bolts. New bolt specifications have been added to include small diameter high strength bolts. The entire revision has been coordinated with the provisions of AISC, and the latest information available from the Research Council on Riveted and Bolted Structural Joints. For connections in which the thickness of the connected part equals or exceeds 3/16 inches, the designer is referred to the AISC specification.

A few additional changes for the provisions on bolted connections are presently under consideration. These additional changes include correlating the definitions of minimum edge distance and inter-bolt spacing with AISC and RCRBSJ. They also include a change in the allowable shear stress for small diameter bolts.

Ductility

New requirements for ductility were also approved on January 25. These new changes reflect the need for special provisions for the full hard grades of ASTM A446 and A611, and the need for a minimum level of ductility for steels not listed

in the material clause. The changes were based in part on research at Cornell University and on the engineering experience and judgment of members of the Advisory Group. For steels not listed in the materials clause, the ratio of tensile strength to yield point must not be less than 1.08, and the total elongation must not be less than 10 percent for a two inch gage length or 7 percent for an 8 inch gage length.

Full hard steels, or other steels not meeting the minimums given above may be used if the basic design stress does not exceed 45 percent of the yield point, or 36 ksi, whichever is lower, and if the suitability of the steel for the application (including connections) is determined by load test. Alternatively, for applications with established performance, no load testing is required subject to approval by the owner's engineer. In either situation, the loads shall not exceed those calculated by using sections 2 through 5 of the specification where applicable.

The changes in the provisions for bolted connections and the new ductility provisions will be published as soon as possible.

PROPOSED MODIFICATIONS

Inelastic Reserve Capacity

Recent research by T. B. Pekoz of Cornell has indicated that for cold-formed members with relatively low width-to-thickness ratios there is an additional load carrying capacity which can be utilized in design. T. V. Galambos is chairman of a subcommittee which is currently studying the specific proposed changes to determine the limits for which this additional capacity may be utilized, the exact procedure for calculation of the additional capacity, and the impact of the change (if approved) on members and panels currently in production.

Unstiffened Elements

Recognition of the post buckling strengths of unstiffened elements by means of the concept of effective width used for stiffened elements is currently under consideration. The ramifications in changing the design procedure for unstiffened elements, particularly on column design, are currently under study by a subcommittee

chaired by L. W. Ife. This study involves the influence of the interaction of web and flange elements in the post buckling range. It may be necessary to wait for completion of additional research on this interaction before it is possible to agree on a change.

Edge and Intermediate Stiffeners

Design procedures for stiffeners may well be the subject of one of the next subcommittee investigations to determine how specification provisions can be extended to give the designer greater freedom. For example, what is the influence of a stiffener which is less than adequate, according to the present specification definition? What is the influence of a stiffener which is more than adequate? What is the influence of stiffeners which themselves may be subject to local buckling?

Web Design

Extensive research on web design under the direction of Wei-Wen Yu will result in a proposal of revisions for all aspects of web design: shear, bending, crippling, and their interactions. It may also result in provisions for design of web stiffeners. The results of the research are already being utilized in the current intensive study of the web crippling and bending interaction provisions included in addendum no. 2.

Bracing Requirements

For a number of years, work has been underway in an effort to eliminate the troublesome footnote to section 5.2., channel and Z-sections used as beams. This footnote says that bracing may, or may not, be required to prevent twisting. This leaves the designer at loose ends. The Metal Building Manufacturers Association and AISI have been cooperating in sponsoring work on this topic for some time. A research project soon to be initiated by Teoman Pekoz should provide the last missing element of information on the ultimate strength of such sections so that a specific design procedure can be recommended.

Existing provisions for bracing wall studs are old and do not reflect current practice and sheathing materials used and do not permit realistic treatment of the actual interaction of studs and sheathing material. Work is underway on how a computer program which handles this design problem can be made readily usable by the designer.

Design of braces is also under study. The seemingly abritrary provision for minimum spacing of braces may be liberalized, and an apparent anomaly in the strength design for braces should be resolved.

Fusion Welding

American Welding Society will issue a design specification for welding thin steel in the near future. The AWS specification will contain detailed provisions for welding procedures, welder qualification, and calculation of allowable load for field fusion welds, including arc spot welds commonly used in welding sheet material. Publication of the AWS document will enable the Advisory Group to make a major revision and updating of the cold-formed fusion welding provisions. For the first time, the cold-formed steel designer will have provisions specifically intended for sheet steels, and not a makeshift adaptation of welding provisions for heavier structural steels. The AWS Structural Welding Committee and the Advisory Group now have parallel subcommittees which will work hand-in-hand to ensure that no conflict will exist between the AISI and AWS specifications.

POTENTIAL FUTURE REVISIONS

Members containing elements with holes, so-called perforated elements, have long been outside the scope of analytical design procedures in the cold-formed specification, and reference has always been made to section 6 for tests. However, it may be possible to put at least a partially analytical procedure in the specification; research toward this end is underway at this time. This effort is bolstered by the approach taken by the Rack Manufacturers Institute in their design specification where a stub column test of a section containing holes is used to determine

the Q factor for column design. It is too early to predict that this approach will be in AISI's specification; however, the designer today is well advised to take a careful look at the RMI approach.

On into the future, probably the most significant advance in the cold-formed specification will be the potential offered by the current work on developing a load and resistance factor design format. This work, underway in a joint project at Washington University and the University of Missouri-Rolla, directed by T.V. Galambos and Wei-Wen Yu, parallels the procedure and philosophy followed in work on an LRFD format for the AISC specification. The realistic assessment of member and connection strength, and realistic recognition of loads, should result in economies for the designer, and more uniform overall safety and reliability.

COLD-FORMED MANUAL

In 1977 AISI published a new edition of the cold-formed manual. Although this manual is still based on the 1968 edition of the specification, it represents a major improvement in format and usability. The page size is now 8 1/2 by 11 inches and the entire manual is in a looseleaf binder. This makes the charts and tables much easier to use, and it makes possible prompt revisions of portions of the manual without waiting for republication of the entire manual or even a part of the manual.

CONCLUSIONS

The work of the Advisory Group on AISI's Specification for the Design of Cold-Formed Steel Structural Members is continually increasing. The assistance of all users of the specification is needed. The Advisory Group is looking for criticism. We will be happy to receive comments on areas where the specification is ambiguous, difficult to understand, restrictive, too conservative, too liberal, or where there are no provisions to meet your particular design needs. Of course, the specification cannot be all things to all people, but we can continue to try to improve it to meet the needs of the design profession and the manufacturer.

TABLE 1

ADVISORY GROUP ON THE SPECIFICATION FOR THE DESIGN OF COLD-FORMED STEEL STRUCTURAL MEMBERS
(MEMBERSHIP FEBRUARY 1978)

K. H. Klippstein Chairman	P	United States Steel Corporation
A. L. Johnson, Secretary	P	American Iron & Steel Institute
R. V. Ault	P	Bowman Const. Prod. - Cyclops
C. R. Clauer	GI	Clauer Associates
D. S. Ellifritt	C	Metal Building Manufacturers Association
E. R. Estes, Jr.	GI	Edward R. Estes, Jr. & Associates
J. M. Fisher	GI	Computerized Structural Design, Inc.
T. V. Galambos	GI	Washington University
R. W. Haussler	GI	Consulting Structural Engineer
R. B. Heagler	C	United Steel Deck, Inc.
L. W. Ife	P	The Steel Company of Canada, Ltd.
B. T. Jones	C	H. H. Robertson Company
T. J. Jones	P	Wheeling Corrugating Company
Herbert Klein	C	Sturdi-Bilt - Unarco Industries
Paul Klim	P	Republic Buildings Corporation
N. C. Lind	GI	University of Waterloo
Martin Malter	C	Roll Form Products, Inc.
T. J. McCabe	P	INRYCO, Inc.
W. A. Milek	GI	American Institute of Steel Construction
W. E. Mueller	P	Armco Steel Corporation
A. J. Oudheusden	P	Bethlehem Steel Corporation
C. W. Pinkham	GI	S. B. Barnes & Associates
N. W. Rimmer	C	Butler Manufacturing Company
P. A. Seaburg	GI	University of Wisconsin
D. L. Tarlton	GI	Canadian Sheet Steel Building Institute
Richard Tomasetti	GI	Environspace - Lev Zetlin Associates
George Winter	GI	Cornell University
D. S. Wolford	GI	Consultant
Wei-Wen Yu	GI	University of Missouri - Rolla
A. S. Zakrzewski	P	Dominion Foundries & Steel, Ltd.
T. B. Pekoz, Associate Member	GI	Cornell University
Freeman Phillips, Associate Member	P	United States Steel Corporation

TABLE 2

PAST MEMBERS OF ADVISORY GROUP

C. G. Culver	National Bureau of Standards
H. R. Fink	Ogden Metal, Inc.
E. B. Gibson	The Steel Company of Canada, Ltd.
S. H. Iyengar	Skidmore, Owings & Merrill
R. B. Matlock	Kirby Buildings Systems, Inc.
Reidar Bjorhovde	University of Alberta